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Evaluation of the computed tomographic sentinel clot sign to identify bleeding abdominal organs in dogs with hemoabdomen

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Abstract: The CT ”sentinel clot sign” has been defined as the highest attenuation hematoma adjacent to a bleeding organ in humans with hemoabdomen. The aims of this retrospective descriptive multicenter study were to describe CT findings in a sample of dogs with surgically or necropsy confirmed intra-abdominal bleeding and determine prevalence of the ”sentinel clot sign” adjacent to the location of bleeding. Medical records between 2012 and 2014 were searched for dogs with hemoabdomen and in which the origin of the bleeding was confirmed either with surgery or necropsy. Retrieved CT images were reviewed for the presence and localization of the ”sentinel clot sign,” HU measurements of the ”sentinel clot sign” and hemoabdomen, and presence of extravasation of contrast media within the abdominal cavity. Nineteen dogs were included. Three dogs were excluded due to the low amount of blood that did not allow the identification of a ”sentinel clot sign.” A ”sentinel clot sign” was detected in the proximity of the confirmed bleeding organ in 14/16 (88%) of the patients. The mean HU of the ”sentinel clot sign” was 56 (range: 43-70) while that of the hemoabdomen was 34 (range: 20-45). Active hemorrhage was identified as extravasation of contrast medium within the peritoneal cavity from the bleeding organ in three dogs. In conclusion, the CT ”sentinel clot sign” may be helpful for identifying the source of bleeding in dogs with hemoabdomen.

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EVALUATION OF THE COMPUTED TOMOGRAPHIC "SENTINEL CLOT SIGN" TO IDENTIFY THE BLEEDING ABDOMINAL ORGAN IN DOGS

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Abstract:

The computed tomographic "sentinel clot sign" indicates the presence of highest-attenuation hematoma adjacent to the bleeding organ in humans with hemoabdomen. The aim of our study was to verify if the "sentinel clot sign" might represent a useful computed tomographic feature to detect the origin of the bleeding in dogs with hemoabdomen. Medical records between 2012 and 2014 were searched for dogs with hemoabdomen confirmed either with surgery or necropsy. Nineteen cases were included and CT images were reviewed for the presence and localization of the “sentinel clot sign”, HU measurements of the “sentinel clot sign” and hemoabdomen, and presence of extravasation of contrast media within the abdominal cavity. The “sentinel clot sign” was identified in 16 of 19 (84.2%) dogs and was localized in proximity of the bleeding organ in all of them. The mean HU of the “sentinel clot sign” was 56 (range: 43-70) while that of the hemoabdomen was 34 (range: 20-45). Active bleeding was identified as extravasation of contrast media within the peritoneal cavity from the bleeding organ in three dogs. In conclusion, the “sentinel clot sign” may be a helpful computed tomographic feature to identify of the origin of bleeding in dogs with hemoabdomen.

Key words: sentinel clot sign, computed tomography, small animals, canine, spleen

Introduction

Accumulation of blood within the peritoneal space is defined as hemoabdomen, which could be traumatic or nontraumatic in origin (Pintar 2003). Causes of traumatic hemoabdomen include road traffic accident or puncture wounds with bleeding being secondary to ruptured intra-abdominal organs such as spleen and liver (Stephen 2009) or important abdominal vessels. Nontraumatic hemoabdomen, also called spontaneous hemoabdomen, is usually secondary to malignant neoplasia with hemangiosarcoma being more frequent (Pintar 2003). Other causes of nontraumatic hemoabdomen include other types of intra-abdominal neoplasia, coagulopathies, gastric dilatation and volvulus, liver lobe torsion, and splenic torsion (Brockman 2000).

In human, computed tomography (CT) has been demonstrated to have high sensitivity for detection of small bleeding in the peritoneal cavity (Federle 1981). Computed tomographic features such as localized blood clot, active arterial extravasation and mesenteric hyperattenuating triangular fluid collection help the radiologist to locate sources of intraperitoneal hemorrhage in order to choose the best treatment (Lubner 2007). Attenuation measurement of the abdominal fluid allows to make a distinction between different types of effusion (Lubner 2007) and hence between different phases and aging of the bleeding (Orwig D, Federle MP. Localized Clotted Blood as Evidence of Visceral Trauma on CT: The Sentinel Clot Sign. AJR 1989;153:747-749). Clotted blood has a different CT appearance than lysed blood clot or free-flowing blood because of greater density and hemoglobin content (Alexander ES, Clark RA. Computed tomography in the diagnosis of abdominal hemorrhage. JAMA 1982;248:1104-1107; Wolberson MK, Crepps LF, Sundaram M, et al. Hyperdensity of recent hemorhage at body computed tomography: incidence and morphologic variation. Radiology 1983;149:779-784; Swenson SJ, McLeod RA, Stephens DH. CT of extracranial hemorrhage and hematomas. AJR 1984;143:907-912) and the highest-attenuation hematoma, also called "sentinel clot sign", is the one nearest to the source of bleeding. Fluids having density similar to water (bile, urine, intestinal content) have been reported to have Hounsfield Units (HU) that range from 0 to 15 (Lubner 2007). Blood has higher attenuation than watery-dense fluids with unclotted extravascular blood usually being 30-45 HU (Lubner 2007) while the attenuation of clotted blood ranges from 45 to 70 HU. Evaluation for the presence and location of the "sentinel clot sign" is based on the quantification of HU of the abdominal fluid in order to identify which organ is bleeding. The highest-attenuating hematoma is expected to be close to the site of bleeding, whereas lower-attenuating unclotted blood is located farther from the source (Orwig 1989). In veterinary medicine, Focused Assessment with Sonography in Trauma (FAST) scan has been used to evaluate and monitor the presence of hemoabdomen in patients with blunt abdominal trauma, but nothing is reported regarding the use of CT (Boysen 2004).

The aim of this study was to evaluate the usefulness of the "sentinel clot sign" using CT in dogs with hemoabdomen in order to recognize bleeding and localize its origin.

Materials and Methods

Surgical reports databases of the Clinica Veterinaria dell'Orologio, the Centro Diagnostico Veterinario TAC Luni Mare and the Istituto Veterinario di Novara were retrospectively reviewed to identify dogs with traumatic and non-traumatic hemoabdomen that underwent surgical intervention from 2012 to 2014. Dogs were included if at least pre-contrast abdominal CT was performed and if the origin of the bleeding was confirmed with surgery or necropsy, or was confirmed by active extravasation of contrast media within the peritoneal cavity on the multidetector CT (MDCT) angiographic images.

Images from the three institutions were reviewed independently by three board-certified radiologists (SS, FR, VP) using a commercial DICOM viewer (OsiriX, © Pixmeo SARL, 2003-2016) for the presence and localization of the "sentinel clot sign" that was defined as a focal area of increased attenuation in the free peritoneal blood, for HU measurements of the "sentinel clot sign" and of the hemoabdomen, and for the presence of extravasation of contrast media within the abdominal cavity that was defined as presence of high attenuating heterogeneous material in proximity of the sentinel clot sign on the post-contrast images. For the evaluation of the HU of the "sentinel clot sign" and hemoabdomen, observer traced a region-of-interest (ROI), as large as possible, on the interested area in the pre-contrast images, including free fluid and presumed blood clots, using a soft tissues window.

Results

Nineteen dogs met the inclusion criteria, two from the Clinica Veterinaria dell'Orologio, eleven from the Centro Diagnostico TAC Luni Mare and five from the Istituto Veterinario di Novara. Mean age was 11 years (range from 5 to 15). In three dogs there was too small amount of hemoabdomen that limited the delineation of blood clots and hence the detection of the "sentinel clot sign". Therefore, the "sentinel clot sign" was identified in 16 of 19 (84.2%) dogs.

Overall, there were two neutered males, six intact males, six neutered females and two intact females. Breeds included five mixed breed dogs, two Labrador Retrievers and one of the following: German Shepherd, German Shorthaired Pointer, Cocker Spaniel, Boxer, Brittany Spaniel, Cane Corso, Belgian Shepherd and Chihuahua.

All dogs had been imaged with a MDCT unit. Studies were performed either with a 16-row MDCT unit (Clinica Veterinaria dell'Orologio - Light Speed 16 slices, GE Medical Systems, Milan, Italy), with a 4-row MDCT unit (Istituto veterinario di Novara - Light Speed, GE Medical System, Bergamo, Italy), or with a 2-row MDCT unit (Centro Diagnostico TAC Luni Mare - High Speed MXI, GE Medical Systems, Milan, Italy). Animals were anaesthetized and placed in ventral or dorsal recumbency on the CT table. Positive pressure ventilation was employed during image acquisition to prevent motion artifacts. At the CVO, images were acquired in helical scan mode, at 120 kV and 160-210 mAs tube settings, a pitch of 0.562:1 and 1.25 mm slice thickness with 50% overlap with a 0.7 s rotation time and reconstructed with a non-enhancing non-smoothing algorithm. At the TLM, images were acquired in helical scan mode, with a pitch of 1.5, slice thickness of 3 mm, 0.7 s tube rotation time, 120 kV and 160-200 mAs. Contrast-ehnanced images were obtained using a dosage of 450 mgI/kg of ioversol (Optiray, Mallinckrodt Pharmaceuticals, Segrate (MI), Italy). At the IVN, images were acquired in helical scan mode, at 120 kV and 200-220 mAs tube settings, using a pitch of 1.5, 1.25 mm slice thickness and a speed acquisition of 7.5 mm/sec. In all institutions, contrast-enhanced images were then obtained using a dosage of 640 mg I/kg of iodixanol (Visipaque 320, GE Medical Systems, Milan, Italy) injected into a cephalic vein with a power injector (Medrad Italia, Cava Manara, Italy) through an IV catheter.

The presence and localization of the "sentinel clot sign", HU values of the hemoabdomen and of the "sentinel clot sign", and the origin of the bleeding according to surgery or necropsy, or based on extravasation of contrast media on MDCT angiographic images are reported in table 1. The "sentinel cloth sign" was localized in proximity of the bleeding source as confirmed with surgery or necropsy in 14 of 16 (87.5%) dogs. The mean HU of the "sentinel clot sign" was 56 (range from 43 to 70) while that of the hemoabdomen was 34 (range from 20 to 45).

Active bleeding was identified on post-contrast CT images by the presence of a serpiginous or amorphous highly attenuating area originating from an organ parenchyma, consistent with leakage of contrast media within the peritoneal space from the bleeding organ. Active bleeding was detected on MDCT angiography in three patients that had extravasation of contrast media within the peritoneal cavity from the bleeding organ.

Discussion

This study shows that the “sentinel clot sign” based on CT is very frequent in dogs with abdominal bleeding and is helpful to identify the origin of bleeding. In humans, this sign has been reported to be more obvious compared to the computed tomographic parenchymal lesions in some patients (Orwig, 1989).

In our group of dogs, HU ranged from 43 to 70 for the “sentinel clot sign” and from 20 to 45 for the hemoabdomen. These values are similar to those previously reported in humans (Lubner 2007).

Hemoabdomen can usually be distinguished from other fluid due to its higher attenuation value. Fluids that have similar attenuation as water have HU values that range from 0 to 15 HU (Lubner 2007). The HU of the hemoabdomen are influenced by the hematocrit of the patient and the attenuation value of the blood may decrease in patients with hemorrhages that persist more than 48 hours (Orwig 1989). The age of the patient, the extension of the bleeding and the localization have been also reported as factors affecting the attenuation values of the hemoabdomen (blood in the belly). We did not evaluate the hematocrit of our patients and future prospective studies are necessary to identify a possible correlation between the HU of the hemoabdomen and the hematocrit in dogs.

No contrast enhancement of the “sentinel clot sign” is expected on the post-contrast study. If there is progressive increased attenuation of the “sentinel clot sign” on post-contrast images, even if contrast media extravasation is not observed, active bleeding should be suspected. Base on this, the evaluation of the HU of the “sentinel clot sign” should be always performed with a ROI. In a previous study, attenuation values of extravasated contrast material ranged from 85 to 370 HU, with a mean of 132 HU (Shanmuganathan 1995).

In humans, many cases of hemoabdomen can be non-surgically managed with excellent results (Patcher 1996, Croce 1995), but CT evidence of extravasation of contrast media suggests active bleeding and need for urgent surgical treatment or embolization (Shanmuganathan 1995, Fang 1998, Fang 2000). Additional studies are needed to understand the role of CT in assisting choice between surgical versus conservative treatment in dogs with hemoabdomen, in particular in those with traumatic cause.

In the present series, 11 out of 16 dogs with hemoabdomen had a splenic mass. This finding is in line with a previous report showing that splenic hemangiosarcoma is the most common cause of spontaneous hemoabdomen in this species (Pintar 2003).

Three dogs had a too small amount of free fluid and no “sentinel clot sign”. As reported by others in humans (Orwig 1989), this represents a diagnostic limit of the CT. Therefore, absence of the “sentinel clot sign” may not fully exclude bleeding in some cases.

To overcome the presence of a small amount of free fluid we suggest to use a narrow window to improve the detection of the highly attenuating “sentinel clot sign”. On the contrary, for the evaluation of active extravasation of contrast media, a wide window was necessary to avoid confusion between mineral structures and small amount of free peritoneal contrast media.

In conclusion, the “sentinel clot sign” based on CT assessment of dogs with hemoabdomen was visible in the majority of cases and appeared as a highly attenuating amorphous area compared to the rest of the peritoneal effusion. Furthermore, we described for the first time extravasation of contrast media during MDCT angiography as computed tomographic sign of active bleeding. Identification of the “sentinel clot sign” may be helpful in recognizing the origin of abdominal bleeding and special attention should be drawn to detect this feature if organ rupture is suspected in dogs with hemoabdomen.

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Figures and Legends:

Figure 1: Transverse pre (A) and post-contrast (B) MDCT images of a dog with hemoabdomen. Note the presence of a large amount of peritoneal effusion consistent with blood. There is an irregular area of increased attenuation of the peritoneal fluid proximal to the ventral margin of the spleen with no contrast enhancement (arrow heads) consistent with a “sentinel clot sign”.

Figure 2: 3D volume rendering (A) and oblique post-contrast maximum intensity projection (B) of the liver of a dog with hemoabdomen. There is irregular appearance of the cranio-ventral margin of the liver on the 3D volume-rendering image with focal accumulation of contrast medium in the peritoneal space adjacent to it (asterisk on images A and B). This is consistent with active extravasation of contrast media secondary to rupture of the liver parenchyma and it is surrounded by a non-enhancing “sentinel clot sign” (image A, arrow heads). On the oblique MIP image the hepatic vessel responsible for the active extravasation is identified (white arrows)

Table 1. Dogs with hemoabdomen. Bleeding organ, localization of the ”sentinel clot sign”, and mean attenuation of the "sentinel clot sign" and effusion are listed.

Dog	Bleeding organ	Localization of SCS	Mean HU SCS	Mean HU effusion
1	liver	caudal to the spleen	57	45
2	spleen	caudal to the spleen	50	34
3	spleen	caudal and left lateral to the spleen	59	31
4	spleen	ventral to the tail of the spleen	53	39
5	spleen	spleen	50	32
6	liver	caudal to the liver	70	33
7	liver	liver	50	30
8	peritoneal mass	cranial to the urinary bladder	60	32
9	spleen	caudoventral to the spleen	61	20
10	spleen	cranial to the spleen	63	35
11	spleen	left lateral and ventral to the spleen	56	31
12	liver	caudomedial margin of the left medial hepatic lobe	58	37
13	spleen and liver	tail of the spleen	43	35
14	spleen	head of the spleen	55	30
15	spleen	spleen	51	36
16	right adrenal gland	lateral to the right adrenal	66	38

SCS: sentinel clot sign; HU: Hounsfield Unit.